# THE INSTITUTE SPOKESMAN

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NATIONAL LUBRICATING GREASE INSTITUTE


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## Pictures on the Cover

Pictures for the front cover of "The Institute Spokesman" have been very carefully chosen. The final selection of a picture is made because:

(1) It was related to some activity of the Institute, for example, the November, 1946 issue, featuring Mr. H. P. Hobart's picture as the newly elected President of N.L.G.I., and the March, 1947 issue with the birthday cake and candles indicating the tenth anniversary of "The Spokesman."

(2) They are related to the season of the year. The December, 1946 issue with its Christmas greeting is an example.

(3) Or they are related to the industry. The January and February, 1947 issues are examples of this type.

The April issue with its cover picture of a young American riding a tractor, pulling a four-bottom plow, doing a job of spring plowing on a beautiful sloping hillside with a small village in the background, and the picture on this May issue showing a four-row cultivator at work


are not featured in any attempt to revive memories of your boyhood down on the farm or to help sell farm real estate by stimulating the pent-up desire most men have to own a farm. They are shown as a part of a series which will feature agricultural machinery and implements in a variety of operations because it is so closely tied in with the lubricating grease industry.

The American Petroleum Institute has given leadership to a program to link closely two of the nations largest industries—agriculture and petroleum. A.P.I. President, William R. Boyd, Jr., has announced that an Agricultural Development Committee is being formed.

*The* INSTITUTE SPOKESMAN

*Published monthly by*

THE NATIONAL LUBRICATING GREASE INSTITUTE

CARL E. BOLTE ........................ *Editor*

4638 Millcreek Parkway
Kansas City 2, Mo.



Major objectives of the Committee will be:

1. Continued and expanded research into products that combine those on the farm and the oil field, and new uses for them.

2. Study of insecticides, fungicides, weed destroyers, fruit ripeners, liquid fertilizers and similar petroleum products.

3. Furtherance of soil conservation and fertility maintenance programs.

4. Study of efficient and profitable farm mechanization.

"The rapid growth of farm mechanization," said Mr. Boyd, "has made agriculture an important customer of the petroleum industry. It is therefore only

Continued on Page 16

## Technical Committee Appointments

Recognizing the importance of the Technical Committee in the program and activities of the N.L.G.I. and convinced that it is vital that the membership of this committee be kept representative of the whole industry to include those who are keenly interested in the problems of lubricating grease manufacturing, the Executive Committee of the N.L.G.I. at its January 16, 1947, meeting in Chicago recommended that there be a review of the Technical Committee's membership.

This has been done and the following appointments have been jointly made by Mr. Carl W. Georgi, Chairman of the Technical Committee and Mr. H. P. Hobart, President of the N.L.G.I.

Mr. J. A. Altshuler
Stratford Engr. Co.
1414 Dierks Bldg.
Kansas City, Missouri

Mr. L. L. Davis
Continental Oil Co.
Ponca City, Okla.

Dr. J. C. Geniesse
Atlantic Ref. Co.
Box 8138
Philadelphia 1, Pa.

Mr. J. W. Newcombe
Petroleum Chemicals Dept.
Monsanto Chemical Co.
1700 S. Second St.
St. Louis, Missouri

Mr. G. A. Round
Socony Vacuum Oil Co., Inc.
26 Broadway
New York, N. Y.

These men in addition to those listed on page two of the February, 1947, issue of "The Institute Spokesman" constitutes the present membership of the N.L.G.I. Technical Committee.

## New N.L.G.I. Technical Bulletin Still Available

The National Lubricating Grease Institute's latest technical bulletin entitled "Determination of the Flow Characteristics of Lubricating Greases," has been in great demand and enjoyed an international distribution.

In addition to the several hundred copies that have been sent here in the United States recent mailings have been made to Canada, England, France, South Africa, Iran and Sweden.

This new technical bulletin was described at length on page two of the December, 1946, issue of "The Institute Spokesman." It is being called to your attention here in case information about this bulletin might have evaded you.

Copies of the N.L.G.I. bulletin on "Determination of the Flow Characteristics of Lubricating Greases" may be secured from Mr. Carl E. Bolte, Executive Secretary, National Lubricating Grease Institute, 4638 Mill Creek Parkway, Kansas City 2, Missouri, at the cost of one dollar per copy.

Presented at the Annual Convention National Lubricating Grease Institute, Chicago, Ill., 30 Sept. - 2 Oct., 1946

# EVALUATION OF *High Temperature* GREASES

by ROBERT C. ADAMS and SIDNEY M. COLLEGEMAN

U. S. Naval Engineering Experiment Station, Annapolis, Maryland

### About the Authors

*Mr. Sidney M. Collegeman was born in Denver, Colorado, in 1912 but moved to Washington, D. C., at an early age. As a result, most of his education was obtained in that city. He received a B. S. degree in chemistry from the George Washington University in 1936. While taking advanced courses in chemistry he was employed as a graduate assistant at George Washington. Mr. Collegeman also was employed at the National Bureau of Standards in the Photographic Laboratory for a short time before coming to the Naval Engineering Experiment Station in 1938. He became leader of Grease Unit in the Chemical Laboratory at the Station in 1944. He is a member of the American Chemical Society.*

*Mr. Robert C. Adams was born in Douglas, Wyoming, 1905. He attended some fifteen schools in six western states, while following the business wanderings of the family, finally graduating from high school in Wheatland, Wyoming, in 1922. He attended Colorado Agricultural College and University of Michigan, interrupting this for a year of teaching a one-room mountain school, and was awarded degrees of A. B. (1927) and M. S. E. (1930) from the latter. Employed as a Chemical Engineer in the Experimental Plant of DuPont Ammonia Corporation, Belle, West Virginia, for somewhat over a year before he came to Annapolis. At the Experiment Station, he served first as Chemical Engineer for the U. S. Shipping Board, a joint investigation with the Navy of Boiler Water Treatment for Marine and Naval Vessels and then joined the staff of the Station in 1933. Mr. Adams has served*

Mr. R. C. Adams delivering this paper before the 14th Annual N.L.G.I. Convention

*the Station as head of the Research Section, Chemical Laboratory, and currently, as Assistant Superintendent of the Chemical Laboratory. The author or joint-author of approximately a dozen papers on Water Treatment and Analyses, Evaluation and Testing of Lubricants which have been presented before the National Lubricating Grease Institute, American Society for Testing Material, American Society of Mechanical Engineers, and American Society of Naval Engineers. A member of the American Institute of Chemical Engineers and American Society for Testing Materials.*

**EDITOR'S NOTE:**
**The opinions expressed in the following article are those of the author. "The Spokesman" takes no credit and assumes no liability therefor.**

Evaluation of High Temperature Greases (1) by Robert C. Adams and Sidney M. Collegeman (2).

The primary purpose of the testing of lubricants, of which high-temperature greases are only a single class, is the determination of their suitability for specific applications. Of almost equal importance, although its secondary nature is not always clearly recognized, is obtaining the evaluation quickly, economically and reproducibly. During the press of war the urge for speed was so overwhelming that a greater reliance than desirable had to be placed on judgment and hypothesis instead of upon data. It should now be possible, however, to base decisions upon the results of tests whose reliability and significance are subject to accurate appraisal. This paper presents a history of the development by the Navy of methods for the evaluation of high-temperature greases and outlines the program for future study to be undertaken by the Experiment Station.

Evaluation should precede specification but ten years ago the only accepted methods of test were those of the ASTM, which even today are inadequate for identification much less evaluation. However, specifications were constructed on this rickety base although a statement of limits for manufacturing formula and such properties of the finished product as penetration and dropping point should more properly be termed a *prescription*. The evident lack of evaluation in the prescription or composition type of specification invites the unscrupulous manufacturer to offer the cheapest product which will meet the more discriminating requirements and circumscribes the efforts of the competent and progressive manufacturer who is continuously improving the quality of his product. Military demands for reliable greases suitable for the extreme conditions of continuous duty at high rates required of fighting vehicles, aircraft and ships evoked a new concept in grease specifications.

The genesis of performance specifications for greases was discussed in 1941 (3). The fallibility of composition specifications had been recognized earlier and the need for better lubricants had been partially satisfied by accepting the recommendations of equipment manufacturers. These recommendations were based upon trials which the manufacturers had made of various greases for lubricating their products. The armed services thus undertook to maintain stocks of many proprietary greases for the variety of devices which they use. This policy developed an intolerably complex supply problem. It is not reasonable that two generators, or reduction gears, or plug valves, of similar service, rating, speed and temperature should require different greases simply

(1) The opinions expressed in this paper are those of the authors and are not necessarily official opinions of the Engineering Experiment Station, the Navy Department or the Institute Spokesman.

(2) Respectively Assistant Superintendent and Grease-Unit Leader of the Chemical Laboratory, U. S. Naval Engineering Experiment Station, Annapolis, Maryland.

(3) Proceedings American Society for Testing Materials, Volume 41, Pages 1095-1194 (1941).

because they came from different factories.

In an effort to clear this fog it was reasoned that if the torque necessary to restrain the outer race of a lubricted bearing on a rotating shaft could be measured accurately, the resulting graphs of torque vs. speed, torque vs. time and torque vs. temperature could be correlated with the service record of greases which had been used successfully to provide a rapid method of evaluation. The device constructed to carry out this idea was the Navy Grease Machine illustrated in Figure 1. Experience showed that the only way to obtain reproducible results with the machine was first to insure uniform packing of grease and then to operate at constant speed and temperature. The parts of the bearing packer also are shown in Figure 1. Complete delineation of the four dimensions of torque, time, temperature and speed was

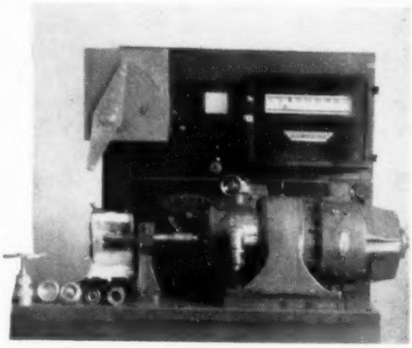

Figure 1.
Navy Grease Machine and Bearing Packer.

intolerably time-consuming so that specimen conditions of temperature and speed had to be selected. Two sets of conditions were employed: 600 r.p.m. at 100° F. and 3000 r. p. m. at 400° F. (later 350° F.). It was also found that deterioration of the grease during service at high temperature could not be measured on the small amount of residual lubricant in the bearing of the Navy Grease Machine. The Navy Grease Beater, shown in Figure 2, was built to provide accelerated oxidation of grease somewhat similar to deterioration in service. In the Beater approximately a pound of grease could be re-circulated through a rapidly rotating bearing while being maintained at an elevated temperature (400 or 350° F.). After oxidation in the Beater, the beaten grease was re-tested in the Navy Grease Machine to determine the change in its properties as reflected by the torque-time curves.

Demands for new guidance in purchasing were so insistent that it was not posible to confirm the validity of NGM criteria by correlation with service tests. Instead, the first specification was pre-

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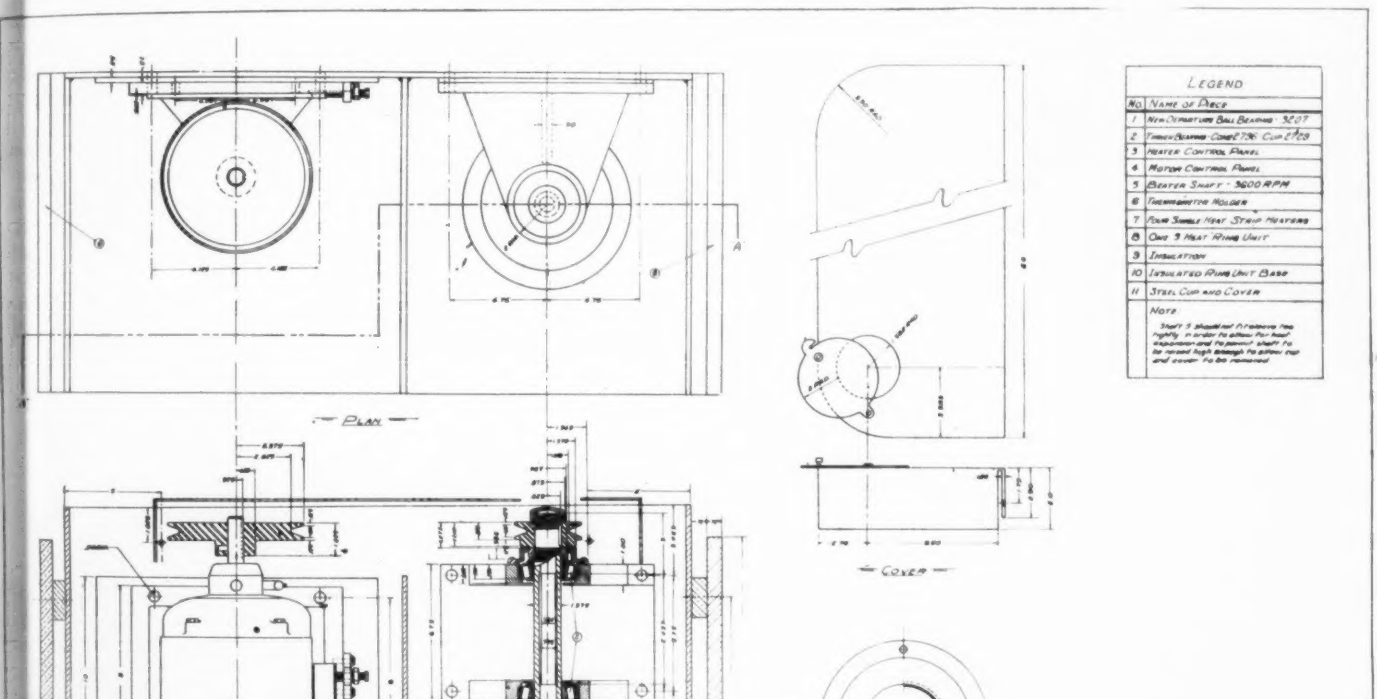
Figure 2. Navy Grease Beater.



# President's Column . . .

GREASE—ITS CONTRIBUTION TO INDUSTRIAL PROGRESS

H. P. Hobart, President N.L.G.I.

Early man discovered that much of the work and effort of moving large stones could be saved if fluid friction was substituted for solid friction. This substitution of fluid for solid friction is the basis of all lubrication. Man later found that large blocks of stone could be moved with very much less effort if rolled along on round bars, thus substituting line contact and rolling friction for surface contact and sliding friction.

With the invention of the wheel and axle, believed to have been used by the Mesopotamians as early as 4000 B. C., some form of lubrication became a practical necessity.

Our modern intricate machines could produce little or nothing without lubrication. The fine efficient lubricating oils and greases which have been developed in recent years contribute enormously to faster, smoother and better operation of these machines, which means greater production, finer workmanship and greater reliability.

Line friction is well exemplified by the modern roller bearing, and point friction by the modern ball bearing. Theoretically these require little lubrication, but practically, the life of these bearings is enormously extended when greases are used to protect the finely polished metal surfaces inside the bearings, to keep moisture, dust and abrasive matter out of the bearings, preventing wear and rust.

Present conceptions in molecular theories envisage solids when the average distance between the constantly vibrating atoms remains constant and fluids when that distance is constantly changing.

While certain greases may appear to some as solids, all greases work as fluids and substitute fluid friction for the much greater friction between solid surfaces.

While the public in general now regards lubrication as essential, probably few realize the full importance which lubrication plays in our daily life.

To bring this out clearly, let us picture what would happen if, by magic, all lubrication should stop some day at midnight. On getting up the next morning if we turned the electric light switch we would have no light—if we turned the faucet we would have no water—there would be no electricity—there would be no gas to cook with—no news paper—no telephone—no street cars—no trains—no motor cars.

We could walk to the office but elevators would not be running—there would be no artificial heat in the building—no mechanical service of any kind. No refrigeration—soon food supplies in the larger cities would run out but they could not be replaced for lack of me

chanical transportation. The hands of time would have been turned back and our modern cities would become desolate.

When we clearly understand how valuable lubricants are when measured by the service which they perform, if we stop to realize that many of these lubricants cost less than many grades of bottled drinking water, we can then appreciate what a truly magnificent job manufacturers of lubricating oils and greases have done in providing industry with the present highly efficient lubricants and the remarkable distribution system which brings them to automotive and industrial consumers all over the country with a maximum of convenience.

At this point many readers may, quite naturally, ask—if the object of lubrication is to substitute fluid friction for solid friction why do we need the more solid appearing form of lubricant known as grease?

The answer is largely one of mechanical requirements and design limitations. Most greases consist principally of lubricating oils to which various types of soaps or mixtures of soaps, and possibly other materials, have been added. The principal contribution of these soaps is not directly that of lubrication but to help the soap-thickened lubricant to stay in place.

This is where greases perform an extra service to industry and save industry a great deal of money. Because of the soaps in the grease, greases will stay in ball, roller and plain bearings where oils might run out or be thrown out by centrifugal force. If oils were used in such bearings the bearings would have to be made oil-tight or practically oil-tight or the lubricating system designed to provide a continuous supply of oil to the bearing. In the latter case, provision might have to be made to prevent oil thrown from the bearing damaging fabrics or other materials in process.

To make such bearings oil-tight would, in many cases, necessitate packing glands or other relatively bulky provisions.

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# EVALUATION OF *High Temperature* GREASES

Continued from Page 5

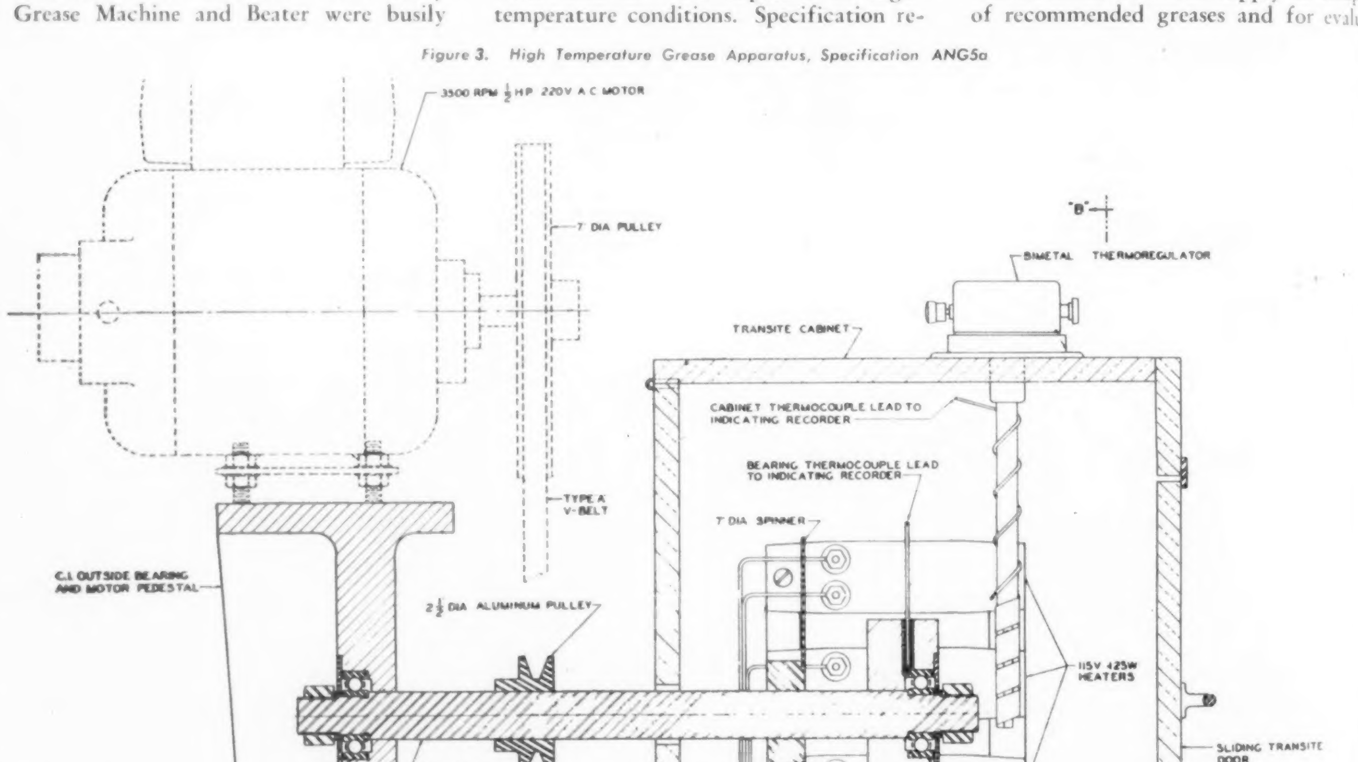
pared by removing empirical limits above and below the torque-time curves traced by what appeared to be the best of several greases tested. Reports of unsatisfactory high-temperature grease from Naval aircraft decreased gratifyingly and the improvement was prematurely attributed to this new specification.

The grease was better than the Navy had obtained previously but only one manufacurer, that of the prototype, qualified under the specification. Because of the need for speed in wartime, coupled with the fact that only one product appeared in the bulletin of approved materials, inspection tests of early deliveries were omitted. The Navy Grease Machine and Beater were busily engaged in qualification tests for other manufacturers with consistently unsatisfactory results. Eventually an inspection test was made on a delivery of the approved material and it failed! Obviously the tests of the specification did not measure the significant properties of the grease.

No other equipment for testing high-temperature aircraft greases was available so that the immediately needed revision of the specification had to be based on the Navy Grease Machine and Beater. This temporary specification was an outright hypthecation. It was assumed that the most desirable grease is the one which shows the least change in torque with time or with exposure to high-temperature conditions. Specification requirements consisted of a series of maximum permissible ratios between initial torque and final torque on the fresh grease and beaten grease and between the torque measured on the beaten grease and the corresponding value from the NGM run on the fresh grease. Although these criteria are reasonable, we were not too sanguine about the service suitability of products satisfying them. There had been enough of rationalization in the development and some demonstration and data on service performance were needed.

The first step was the design and construction of a new apparatus, the High Temperature Grease Apparatus of Specification ANG5a, shown in Figure 3, in which service operating conditions could be stimulated. Cooperation of the CLLG Group of the Coordinating Research Council, grease makers and manufacturers of aircraft-engine accessories was obtained both for supply of samples of recommended greases and for evalua-

*Figure 3. High Temperature Grease Apparatus, Specification ANG5a*



tion of these greases by both laboratory tests and shop trial in actual equipment.

The ANG5a apparatus turns a lubricated, No. 204, test bearing at 10000 rpm while the bearing is maintained at any desired temperature. All of the recommended greases were tested at 275°, 300° and 325°F to determine their relative service lines. Simultaneously each of the cooperators were supplied with coded portions of each of the same twelve greases. They were requested to subject these portions to any tests they considered appropriate, but to include shop service-tests if possible, to divide the coded greases at least into *satisfactory* and *unsatisfactory* groups and to rate them in order of merit if the test results were sufficiently definitive.

The unsatisfactory service performance of some of the greases supplied under the hypothecated specification made it necessary to issue a new specification based on the ANG5a apparatus before results of tests by the several cooperators had been received. This specification required minimum simulated-service of 300 hours at 300°F and 10000 rpm, the test bearing being stopped and cooled to room temperature daily and all running time being counted as test time. Comparative tests indicated that simulated-service life at 275°F would exceed twice that at 300°F, while that at 325°F would approximate half that at 300°F. The dispersion of results at the highest temperature was considerable, necessitating numerous check runs, while those at the lowest temperature were time consuming. The 300°F temperature was selected for standard tests as that which would permit most rapid progress.

During the development of specifications for high-temperature aircraft greases a similar problem had arisen in the case of ship-board electric motors. New motor materials and design promised electric motors of higher output per unit space and weight if an increase in bearing temperature to 100°C or more could be tolerated. It was desirable to take advantage of this possibility but, "once burned twice shy," the determination should be based upon simulated service tests and not upon results of accelerated tests not verified as representing service conditions.

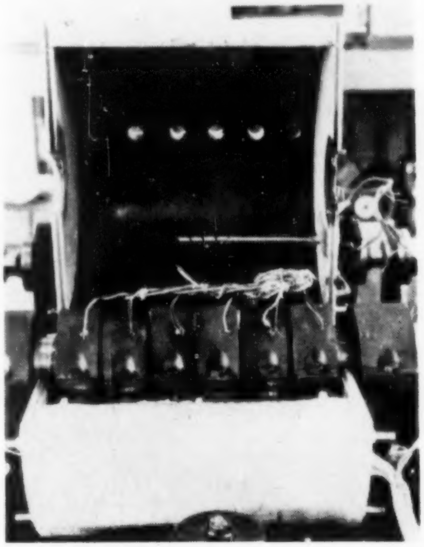


Figure 4.
*Multiple Bearing Grease Testing Unit (Centipede) One of Six Units.*

A multiple-bearing appartus, familiarly called the *centipede*, was built for the comparison and appraisal of electric-motor-bearing greases. The apparatus consists of six rotating shafts each mounted in a separate oven and carrying six, No. 212 bearings. Each of the bearings is enclosed in a cast-iron housing which is lever-loaded to apply a downward force of 150 pounds to the bearing. All shafts, which are arranged in parallel, tandem trios, are belt driven at 1800 rpm by a single motor. One of the six units of the centipede is shown in Figure 4.

The centipede permits eighteen, simultaneous, duplicate test runs and is operated continuously from Monday morning to Saturday evening, approximately 130 hours per week. Each of the six ovens of the centipede has a thermostat to maintain constant air-temperature but the operating temperatures of the six test bearings are not the same, the two center bearings usually being 10° to 20°F hotter than the two end bearings on each shaft. Impending failure of a test bearing can be detected by a rise in temperature or by increase in the noise of the bearing. An effort is made to remove each test bearing just before actual failure occurs because when a test bearing locks considerable damage to thermocouples, heaters and adjoining bearings may result from the inertia of the other rotating parts before safety controls shut off the power.

Tests with the centipede have shown that high quality greases will lubricate electric-motor ball bearings at an operating temperature of 100°C (210 + 10°F) for at least 4000 hours. Many greases will give satisfactory lubrication for much longer periods, (one specimen is still running after more than 15000 hours), but 4000 hours, almost six months of running and reasonably representing a year of normal service, is considered adequate. A specification requiring a 4000-hour qualification in the centipede has been issued. (4)

There is no reason to believe that the evaluation of high-temperature greases obtained by those simulated-service tests is not reliable. It must be admitted, however, that the tests are time-consuming, particularly the centipede tests which require about eight months. The most pressing need, therefore, is for a means of accelerating the testing so that results can be obtained in a shorter time. Ideally, it should be possible to apply the test for inspection of each delivery lot, which would require reduction of testing time to not more than three days. Such a manifold acceleration of testing conditions and reduction in testing time must be achieved by many successive steps, each corroborated by correlation with the results of the preceding step, if the present reliable evaluation is not to be imperiled. Furthermore, each step from simulated-service to highest acceleration must be conducted in the same testing machine if past history of a new design and a new testing device for each new problem is to be avoided.

In an effort to provide this Universal Grease Tester the Station has designed the unit illustrated in Figure 5. This unit recognizes and provides control for four variables: temperature, speed, bear-

(4) Navy Department Specification 14-L-3c; Lubricant, Ball and Roller Bearing; 15 Jan. 1946.

ing size and bearing load. Permissible temperatures with the present installation range from room up to 500°F; speed, up to 20000 rpm; bearing size, up to 60 mm bore; and bearing load, up to 50 pounds. Temperature and load ranges could be extended readily by minor modifications of accessories without any essential change in the testing unit.

Thirty Universal Grease Tester units have been installed in a compact assembly wherein one operator with semi-automatic controls can achieve approximately 600 bearing-test hours per day. This installation is illustrated in Figures 6 and 7. The multiple installation is necessary in order to obtain in reasonable time sufficient replica runs for appraisal of both the magnitude and the variability of the results.

The program for study of high-temperature aircraft greases illustrates the projected used of the Universal Grease Testers for development of rapid, reliable methods for performance evaluation of anti-friction bearing lubricants. The

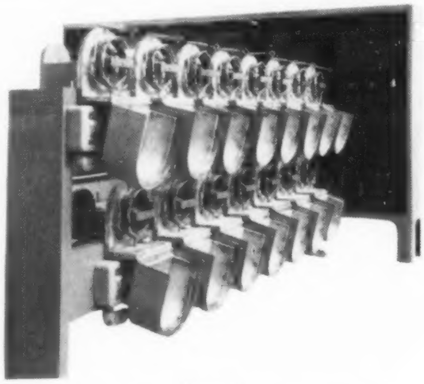


Figure 6.
One Bank of Universal Grease Tester Units, Ovens Open.

greases currently approved under Specifications AN G5a and 14L7 have each been subjected to quadruplicate tests under the conditions of those specifications: 300°F, 10000 rpm, No. 204 bearings. A modified control-chart analysis (5) has

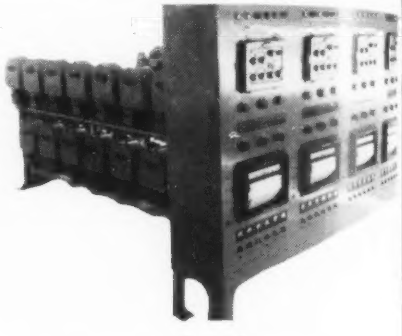
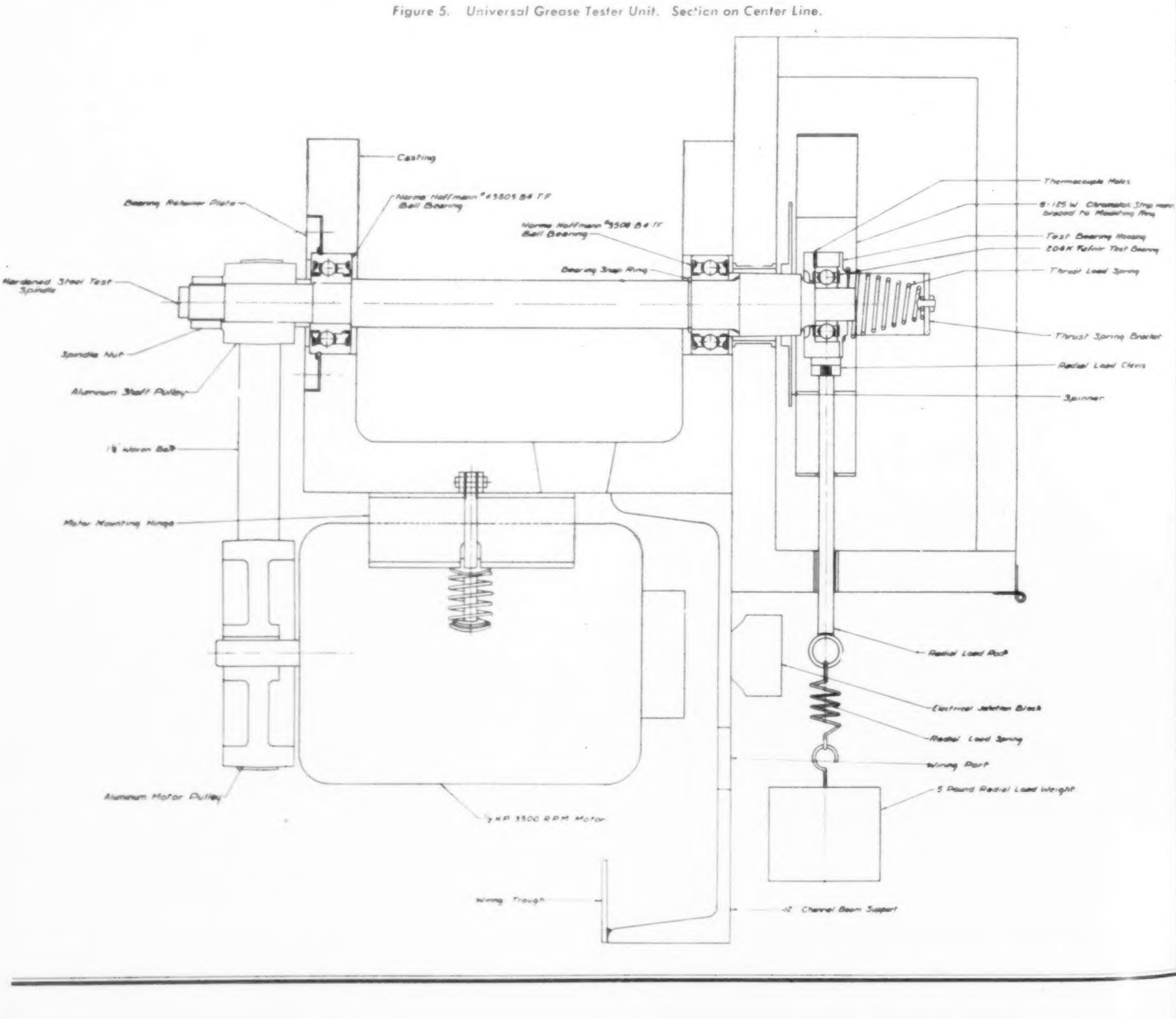


Figure 7.
End of Control Panel and Bank of Units, Ovens Closed.

been applied to the results. This is an admitted misapplication of control charts, which were developed for detection of significant variation in successive lots of

(5) Supplement B, ASTM Manual on Presentation of Data, 1943 Reprint.

Figure 5. Universal Grease Tester Unit. Section on Center Line.



presumably identical material, but the objective and manner of their use it is hoped are not an undue violation of mathematical principles.

The mean, $x$, and standard deviation, $\sigma$, of each set of four tests are calculated and the results plotted on a control chart. Figure 8 illustrates this process with the first thirteen greases tested. The central line in the upper array is the grand average, $x$ of the several individual means and that in the lower array is the mean, $\sigma$, of the several standard deviations. Control limits calculated from $x$ and $\sigma$ (5) are shown as broken lines.

Present interpretation of the results shown in Figure 8 is the following:

1. There is no indication of a significant difference in acceptability or expected service performance among the greases whose $x$ values lie within the control limits.
2. Greases whose $x$ values fall below 275 hours, the lower control limit, are significantly poorer than the average of all greases tested. (In this case none of the greases fell below this figure.)
3. Greases whose $x$ values are greater than 760 hours, the upper control limit, are significantly better than the average of all greases tested (Greases B and G).

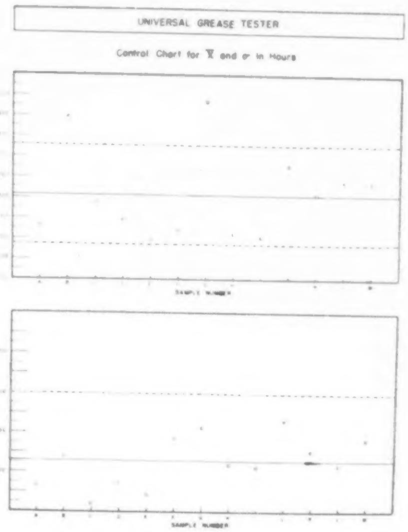



Figure 8.
Control-Chart Summary of Tests on Approved Greases.

4. Any results on a grease whose standard deviation exceeds 300, upper control limit for $\sigma$, are questionable. Such an excessive dispersion in results had it occurred, would suggest that operational errors in selecting, cleaning, packing or mounting test bearings had occurred. Such a set of results should be discarded and another quadruplicate test made.

When such a set of data as shown in Figure 8 is completed, one variable can be intensified and a similar set of data obtained under the accelerated conditions. Only one variable at a time should be changed, to avoid confusion, and the change should be reasonable in amount. In the case of high-temperature aircraft grease, which has served as the example, the first change will be to increase the operating temperature from 300° to 325°F.

When two sets of data differing in only one variable are available, a sound decision as to the interchangeability of the two sets of testing conditions can be made. If the same greases are significantly poorer, and the same greases significantly better, than the average and the dispersion of results is not greatly different, there is no reason why the more severe conditions cannot be used as satisfactorily for specification requirements

Continued on Following Page

with a reduction in testing time. Review of the data also will indicate whether further acceleration by increase in temperature is promising or if another variable, speed or load, should be increased as the next step toward reduction of qualification-test time.

Reduction of the present 4000-hour qualification time for shipboard electric-motor-bearing greases to a few weeks or days will require extended testing. It must follow the method of stepwise correlation to be reliable. Load, speed and temperature must be increased individually in sufficiently short steps to avoid unrecognized exceeding of a critical condition.

Other, more rapidly determined properties of greases should not be forgotten. A perspicacious investigator may at any time discern a correlation between the relative merit of greases so laboriously measured and one or more physical properties easy to determine. For this reason we continue to make chemical analyses, determine physical properties, explore the effect of prolonged working, try wear tests, and study the viscosity-shear-temperature relationships of greases. The Navy Grease Machine and Navy Grease Beater have not been discarded. Out of these corrolary data may come a short cut permitting rapid, reliable evaluation of greases by indirect means.

At the present time, however, there appears to be no royal road to quick evaluation of high-temperature grease. The wonder machine into whose cell a sample of grease is fed while the authoritative judgment of its properties is automatically printed on a record tape is still far away. Too much time already has been lost in fruitless efforts to develop such divining rods. The long and laborious pathway which has been described appears to be the most promising route to reliable evaluation.

**Acknowledgement**

The authors have been assisted by numerous individuals in recent years. Particular acknowledgment of help in design of the present apparatus and program should be made to William C. Clinton, John W. Dudley, Jr., and Royal H. Stone, former members of the Chemical Laboratory, U.S.N. Engineering Experiment Station, and D. E. Batesole and F. L. Wright, of Norma Hoffman Bearings Corporation.

## Big Demand for "Pumpability Symposium" Material

The "Pumpability Symposium" discussion material which was explained in detail on page 3 of the March, 1947, issue of "The Institute Spokesman" has been mailed to all members of the N.L.G.I., the Technical Committee, and the grease dispensing equipment manufacturers.

The original printing order for this material was placed in sufficient quantity to take care of the anticipated demand for additional copies from people outside of these groups, but there is every indication that the supply will be exhausted at an early date and a rerun made necessary. One company has ordered 100 copies. Orders will be filled promptly. Address your request to Mr. Carl E. Bolte, Executive Secretary, National Lubricating Grease Institute, 4638 Mill Creek Parkway, Kansas City 2, Missouri. The cost is one dollar per copy.

## Preprints of N.L.G.I. Convention Papers Available

In the files of the National Lubricating Grease Institute are a number of preprints of papers that have been delivered before N.L.G.I. Annual Conventions in recent years. As a part of the service which the N.L.G.I. renders not only to its members but to the industry at large, these preprints are made available at no cost as long as the supply lasts. Listed here by Conventions starting with the most recent ones, we give the title and author of the papers. Your order for any one or several or all of these papers will be filled promptly. Address your request to Mr. Carl E. Bolte, Executive Secretary, National Lubricating Grease Institute, 4638 Mill Creek Parkway, Kansas City 2, Missouri.

14th ANNUAL CONVENTION (1946)

"Design of Anti-Friction Bearing Installations With Special Reference to Electric Motors" by Walter Saveland, Jr.

"Rapid Method For Determination of Oil in Lubricating Greases" by G. A. Williams and C. J. Boner.

Continued on Page 16

A Paper Presented Before the 20th Fall Meeting American Oil Chemists Society, Edgewater Beach Hotel, Chicago, Ill., Oct. 3[illegible], 194[illegible]

# FATS AND FATTY ACIDS FOR *Lubricating Grease* MANUFACTURE

by C. W. GEORGI and J. B. STUCKER, Technical Committee, National Lubricating Grease Institute

CARL W. GEORGI is Technical Director of the Research Laboratories of the Quaker State Oil Refining Corporation, Vice-President of the Enterprise Oil Company, Buffalo, New York. He is the Immediate Past-President, Chairman of the Technical Committee and member of the Board of Directors of the National Lubricating Grease Institute.

J. B. STUCKER was born in Chicago, Illinois, in 1914. He attended Loyola University and the University of Chicago. Received his B.S. from the latter in 1935. After leaving school he served one-half year with American Boiler and Tank Co. as draftsman, after which he joined the Pure Oil Co. in November of 1935. He has been with Pure for over 11 years, approximately 3 years on general chemical work, 3 years more on cutting oil and extreme-pressure lubes, 2 years as assistant grease plant superintendent, and the last 3 years as group leader in charge of cutting oils, extreme-pressure lubes, greases and heavy-duty motor oil development. Most of his time has been devoted to extreme-pressure lubes and all of his development work leading to patents has been in that field. He served on the CRC working committees on gear oils and greases during the war, on the NLGI Technical Committee and the joint ABEC-NLGI Committee since 1943 and has been active in Sections I, II and III of ASTM Technical Committee G on Greases since its inception in 1945.

*Mr. Carl W. Georgi presiding at the 14th Annual N.L.G.I. Convention, Chicago, Ill., Sept. 30-Oct. 2, 194[illegible]*

*PRELIMINARY REMARKS—With the current shortages of fats and fatty oils of all types, the subject selected for this paper "Fats and Fatty Acids for Lubricating Grease Manufacture" might well be covered by one sentence—We'll take any kind of fat offered and as much as we can get.*

*This discussion is accordingly predicated on normal times—if there is such a thing as normal times—and when manufacturers of lubricating greases can be selective in the types of fatty materials they purchase and utilize.*

*It should also be mentioned that this paper is offered as a presentation of the Technical Committee of the National Lubricating Grease Institute, rather than by the authors as representatives of their respective companies. The various members of the Grease Institute Technical Committee who contributed to this paper will be mentioned later.*

In discussing the subject of fats and fatty acids for lubricating grease manufacture, perhaps the most pertinent questions might be itemized as "What?", "How Much?" and "How?"

As to the questions of what fats, and how much are used by the Petroleum Industry, the reports of the Bureau of the Census are of interest.

**TABLE 1**

**Approximate Annual Consumption of Vegetable Oils By Petroleum Industry**

| | *Pounds* |
|---|---|
| Cottonseed Oil | 600,000 |
| Rapeseed Oil | 10,000,000 |
| Linseed Oil | 500,000 |
| Castor Oil | 700,000 |
| Miscl. Vegetable Oils | 600,000 |
| Vegetable Oil Fatty Acids | 2,000,000 |
| Total | 14,400,000 |

Table 1 shows an approximate summary of the annual consumption of vegetable oils by the Petroleum Industry, as totalized from Bureau of the Census Reports of the past few years. The consumption of vegetable oils by petroleum refiners and compounders is not large, although the utilization of Rapeseed Oil and of vegetable oil fatty acids is noteworthy.

**TABLE 2**

**Approximate Annual Consumption of Animal and Marine Fats By Petroleum Industry**

| | *Pounds* |
|---|---|
| Tallow and Tallow Oil | 43,000,000 |
| Greases and Lard Oil | 40,000,000 |
| Whale, Sperm and Fish Oils | 5,000,000 |
| Wool Grease | 2,400,000 |
| Stearines and Foots Oils | 2,300,000 |
| Red Oil | 2,600,000 |
| Stearic Acid | 4,300,000 |
| Miscl. Fatty Acids | 9,000,000 |
| Total | 108,600,000 |

Table 2 is a similar summary of the approximate annual consumption of animal and marine fats by the Petroleum Industry. The preponderant consumption of tallow and hog fats in relation to other fats and oils, and the utilization of various types of fatty acids is of interest.

Due to the tremendous diversifications of the petroleum industry, both as to the number of refiners, compounders and marketers, as well as to the great variety of fat containing lubricants being manufactured and sold, the Bureau of Census figures very probably do not include a considerable poundage of the fatty materials actually used in lubricants. The total fat consumption by the Petroleum Industry is thus most probably considerably greater than indicated by Tables 1 and 2.

Fats and fatty oils are incorporated in a large variety of lubricants and specialty products such as steam cylinder oils, soluble oils, core oils, rust preventives, surface coatings, cutting oils, extreme pressure lubricants, and so on, in addition to lubricating greases. The Bureau of Census figures include the fats used in all types of petroleum products and thus give only a general or approximate idea of the over-all utilization.

Fairly accurate figures become available on fat consumption specifically for the manufacture of lubricating greases through the medium of reports which grease makers were required to file with the Petroleum Administrator for War.

Figure 3 is a summary of these PAW records. Since all but the smallest grease manufacturers were required to file reports with PAW, it is estimated that about 90% of the grease production in the United States is included therein.

It will be noted that the total production of lubricating greases in the United States in 1943 was of the order of 500,-

1—"Grease Production and Fat-Fatty Acid Consumption by the Lubricating Grease Industry."
Sydney Bevin and C. W. Georgi.
The Institute Spokesman, Vol. VII, No. 12, March, 1944.

000,000 pounds annually and that some 60,000,000 pounds of fats and fatty acids were consumed in the manufacture of

**TABLE 3**
**Lubricating Grease Production and Fat-Fatty Acid Consumption Second and Third Quarters**

| | 1943 Pounds | 1941 Pounds |
|---|---|---|
| Total Lubricating Grease Manufactured | 254,246,000 | 229,381,000 |
| Total Fats Used | 16,313,000 | 20,215,000 |
| Total Fatty Acids Used | 13,896,000 | 8,228,000 |

these lubricants — an average of about 12% total fatty materials in the finished grease lubricants produced.

Information available at the present time indicates that lubricating grease production is at least as great as, if not greater than the 1943 figures.

The higher proportion of fatty acids in relation to fatty glycerides, used in 1943 as compared to 1941, was the result of a Petroleum Administrator order requiring grease makers to use fatty acids wherever possible as a glycerine conservation measure. With the cancellation of this order, it is probable that the fatty acid-glyceride ratio has returned more nearly to that of 1941.

While accurate information is not available, it can be said that the bulk of fatty glycerides used for grease manufacture are tallow and hog greases. The fatty acids used are largely stearic acid, hydrogenated fish oil acids and acids distilled from animal oils. Cotton seed oil fatty acids are used to a considerable extent in times when vegetable oils are more available.

### Properties of Lubricating Greases As Related to the Fat Constituent

In considering the question of how fatty oils and acids are utilized in the preparation of lubricating greases, a brief description of greases and of manufacturing procedures is in order. A detailed discussion is impossible in a paper of this length, and only the "high spots" as related more particularly to fat utilization can be mentioned.

Lubricating greases may be considered to consist of lubricating oils absorbed in a metal soap matrix, this matrix or base being responsible for the plastic and non-fluid characteristics of this type of lubricant. Greases may accordingly be described as fluid lubricating oils which have been converted to a semi-solid or plastic consistency by incorporation of metallic soaps. It has been stated further, that it is the mineral oil constituent of greases which provides the lubricating value and that the soap constituent serves the primary purpose of maintaining the oil in a non-fluid state so that it will adhere to and resist leakage or seepage from lubricated parts or mechanisms.

The particular lubricating oil and the particular metal soap used in preparing a given grease depends upon the specific application for which the grease is intended. Table 4 outlines some of the properties imparted to grease type lubricants by different metal soap bases. Calcium, aluminum and sodium soap base greases constitute the great bulk of those now manufactured and used. Lithium and barium soap greases, as well as soaps of certain other metals, are relatively new developments and their use has so far been restricted to rather specialized applications, due in part to their higher costs of raw materials and processing.

Calcium and aluminum base greases are characterized by smooth, buttery textures, relatively low melting or dropping points, in the order of 200° F., and good water resistance. The term water resistance is generally used to denote the resistance of greases to mulsification and washing on exposure to water or wet operating conditions.

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## Preprints of N.L.G.I. Convention Papers Available

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"Modern Trends in the Application of Lubricating Greases." Charles I. Kraus.

"Continuous Process For Aluminum Grease" by H. G. Houlton.

"Advantages of the Proper Care of Motor Car Lubricants" by D. P. Clark.

"Strontium Greases" by L. W. McLennan and H. J. Worth.

12TH ANNUAL CONVENTION (1944)

"Grease For the Bureau of Ships" by Lt. F. A. Christiansen.

"Some Practical Methods for the Evaluation of Lubricating Greases" by L. W. Sproule.

"Engineering Data," Farval Corp.

"A Machine for Performance Tests of Antifriction Bearing Greases" by Paul G. Exline and S. A. Flesher.

"Report on the Activities of the Coordinating Research Council—War Advisory Committee Grease Advisory Group," W. G. Ainsley.

"Separability Characteristics of Lubricating Greases," T. G. Roehner and R. C. Robinson.

11TH ANNUAL CONVENTION (1943)

"Barium Grease," T. W. McLennan.

"Some Popular Misconceptions about Lubricating Grease," F. L. Koethen.

## Pictures on the Cover

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natural for us to help that customer remain prosperous and to assist him in efficient operation.

"Farmers now use more than three and one-half billion gallons of petroleum products annually and the total is expected to increase. On its part, the petroleum industry uses directly more than 40 million pounds of farm products."

There are approximately 2,200,000 tractors in use on American farms at present, with an expected increase of 200,000 machines a year for the next several years.

## President's Column

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necessitating longer bearing housings. In many designs this extra length is impractical and would offer a serious handicap to compact design, as well as entail considerable extra expense. Many bearings operate in dusty atmosphere and grease seals help immeasurably to protect bearings against dust and abrasive particles in the air. New grease forced into these bearings at proper intervals serves not only to maintain the grease seals but to push away from the bearings old grease on which dust and abrasives may have collected.

Then, too, there are many vertical slides, rods, plungers, chains, gears, wheels, rails, curves, etc., on which it would be difficult to maintain a film of lubricating oil, but where a film of grease can easily be maintained for reasonable periods.

Fundamentally, greases will often stay put where oils would run off, unless more expensive and sometimes elaborate means were provided to maintain an oil film at the particular point of contact where lubrication is required.

There are many greases providing high pressure, extreme pressure, resistance to the washing effect of hot and cold water, steam, alkalies, acids, etc., and other desirable characteristics which are obtained by special compounding more readily with grease than with oil.

Grease, therefore, provides industry not only with good and efficient lubrication but grease also makes possible relatively greater increases in certain characteristics, thus providing more efficient lubricants for certain purposes, and greases also make possible important economies in many designs and many operating economies under certain conditions.

No attempt has been made herein to cover all of the many ways in which greases contribute to industrial progress, but we hope that these few paragraphs will promote a better realization of (1) the important role which grease plays in our daily life, (2) how little modern greases really cost when measured by the outstanding service which they perform, and (3) the never ending contribution which they are making to industrial progress.



## New Advertisers

Again it is our pleasure to greet a new advertiser. Because of space limitations in the April issue of "The Spokesman" no editorial mention was made of this fact, but it is being called to your attention here.

The Pennsylvania Refining Company, with general offices at Butler, Pennsylvania, and branches at Cleveland, Ohio, and Edgewater, New Jersey, have sent us a contract for a one-third page space for the next twelve issues of "The Spokesman," carrying them up to April of 1948. The Pennsylvania Refining Company's advertisement appeared on page fourteen of the April issue and it appears on page (ten) of this issue. A genuine welcome is extended to the Pennsylvania Refining Company as they join that ever-growing group of companies who use the columns of "The Institute Spokesman" to carry their sales message.

## FATS AND FATTY ACIDS
### for Lubricating Grease Manufacture

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Sodium base greases are characterized by a spongy or fibrous texture, high melting or flow points, usually exceeding 300° F., and poor resistance to emulsification by water. Accordingly, calcium or aluminum base greases are preferred in applications where water exposure is anticipated and where operating temperatures are moderate and well below 200° F. Sodium base greases are preferred where wet operating conditions are not involved and where operating temperatures are apt to be high, such as automobile wheel bearings, electric motor bearings and the like.

**TABLE 4**
**Effect of Metal Soap Bases on Properties of Lubricating Greases**

| *Soap Base* | *Grease Structure* | *Approx. Grease Melting Point* | *Resistance to Emulsification by Water* |
|---|---|---|---|
| Calcium | Smooth, Buttery | 200°F. | Good |
| Aluminum | Smooth, Buttery | 200°F. | Good |
| Sodium | Short to Long Fibre | Over 300°F. | Poor |
| Lithium | Smooth, Buttery | Over 300°F. | Good |
| Barium | Short to Med. Fibre | Over 300°F. | Good |
| Mixed Base | Short to Med. Fibre | Over 300°F. | Fair to Poor |

Mixed base greases customarily refer to mixtures of soda and aluminum soaps or soda and calcium soaps. The properties of such mixed base greases are quite similar to straight sodium base greases, since soda soaps are usually predominant.

The newer types of soap base greases, such as lithium and barium, combine the desirable properties of high melting point and good water resistance and have sometimes been referred to as "all purpose" greases, since they do not have the respective limitations of calcium, aluminum or sodium base lubricants. It is possible accordingly, that greases of the lithium and barium soap types may find wider application in the future, particularly if their raw material and processing costs can be reduced to be more nearly competitive with the more common types.

### Grease Texture

The texture of lubricating greases is customarily classified as smooth or buttery, or as fibrous or spongy. The fibre type greases are further divided into general classes of short, medium and long fibre.[2] Figure 5 illustrates typical examples of buttery texture, and short medium and long fibre greases, from left to right respectively. As mentioned previously, calcium, aluminum and lithium soap greases are characteristically of smooth, buttery texture, while sodium, barium and mixed soap base greases are of the fibrous type.


*Figure 5*

### Grease Consistency

Grease lubricants vary in stiffness or consistency from semi-fluid products quite similar to viscous oils, up to very hard greases which must be cut into blocks for handling and application. The degree of stiffness or plasticity of a given grease is dependent upon the concentration of the metallic soap base therein. Small percentages of soap base, in the order of 1 to 5% produce soft, semi-fluid type greases, whereas soap concentrations in the order of 25 to 40% produce the hard, block type greases.

As shown in Table 3, it is interesting that the over-all average soap content of all greases produced is in the order of 12%.

### Calcium Soap Greases

Calcium base greases are prepared by saponifying the selected fat with hydrated lime, usually in the presence of sufficient mineral oil to maintain the soap base in a plastic condition capable of ready mixing and agitation. Saponification under pressure of 15 to 100 lbs. per square inch is frequently used, to insure complete reaction in minimum time. After the so-called soap base is formed, the selected mineral oil is then worked into the base so that a thorough dispersion of the soap in the mineral oil results. Water in concentrations of from a fraction up to several per cent must also be present in finished calcium greases, since the calcium soap-oil system is essentially an emulsion wherein the water acts as a stabilizer or coupling agent.

In general calcium soap greases are made from fats of fairly low titre and moderately high iodine number to secure the best texture and physical stability. Tallow and yellow greases are examples of preferred fats. High titre saturated fats tend to produce calcium base greases of grainy texture and of poor stability as to separation and bleeding of oil.

It is also preferred practice to utilize a preponderance of fatty glycerides in preparation of calcium soaps, since the glycerine liberated acts as a stabilizer of the calcium soap dispersion in the mineral oil.

2—"Structure of Lubricating Greases."
B. B. Farrington and W. N. Davis.
Industrial & Engineering Chemistry, Vol. 28, No. 4, 414-416 (April, 1936).

### Sodium Soap Greases

Sodium base greases are made quite similarly to calcium soap lubricants, the fats being saponified with an aqueous solution of sodium hydroxide. Since the saponification is rapid, open kettles are generally used and pressure saponification is not customary.

The soda soap base is usually processed at high temperatures to drive off the water, after which the mineral oil is worked into the base. Soda soap greases are thus usually substantially anhydrous, and water is not needed as a stabilizer, as is the case with calcium greases.



The type of fat used to make the soda soap base is an important factor in the fibre structure or fibre length of the finished grease. Low titre, unsaturated fatty oils and acids produce finished soda greases of the long fibre type, the fibre structure tending to be tough and elastic. High titre, saturated fats and acids tend to produce greases of the short fibre type. The widest range of fatty materials is accordingly used for soda base greases, with the fats or acids, and very often mixtures of same, being selected to produce the particular type of fibre structure desired for the given finished grease. It is generally preferred to use at least a portion of the total fats as glycerides, since the liberated glycerine serves as a stabilizer of the soda soap-oil structure. However, many of the very hard, block type greases as utilized for mill and railroad lubrication, and where a grease of very short fibre and very high melting point is desired, are made with soda soaps of straight saturated fatty acids, such as stearic or hydrogenated fish oil acids.

The texture or structure of soda base greases is also affected very materially by the details of processing, and manufacturing variations are numerous. These include steam kettle or direct fired kettle preparation, finishing by cold agitation, pan cooling, milling, homogenizing, etc.



### Mixed Base Greases

Mixed base greases are manufactured very similarly to straight sodium base lubricants, the essential difference being that mixtures of soaps such as calcium and sodium, or aluminum and sodium, are formed as the base. In most instances, the soda soap predominates in the mixture and the resultant greases accordingly have properties substantially similar to straight soda soap lubricants. The primary intent of mixed base greases is to secure a very short fibre structure, approaching as closely as possible a smooth or buttery texture, while retaining the high melting point properties of straight soda base lubricants.

### Aluminum Soap Greases

Aluminum soap greases are generally manufactured by dispersing or dissolving commercial aluminum stearate in the selected mineral oil at temperatures in the order of 300° F. The hot soap-oil mixture is then cooled under carefully controlled conditions down to or close to room temperature, after which the cooled grease is usually milled or worked to break down the gel structure into the smooth, buttery texture characteristic of aluminum base greases.

Aluminum stearate used for grease manufacture is prepared by the familiar double decomposition method, involving treatment of a water solution of sodium stearate with a solution of aluminum sulfate or chloride, followed by washing and drying of the precipitated aluminum soaps. Due to the tri-valency of aluminum, three forms of aluminum stearate are possible. Grease making aluminum stearates are usually mixtures, with the mono and di stearates predominating, although commercially pure forms of the mono, di and tri stearates are available.[3]

Commercial stearic acid or hydrogenated fish oil acids are favored for manufacture of aluminum stearates, since high titre, saturated acids provide optimum oil gelling properties and hence form the best and most stable types of aluminum base greases. Aluminum soaps of unsaturated acids, such as oleic, have poor gelling properties and tend to form soft, unstable greases.

It is possible to prepare aluminum soaps by direct reaction of a hydrous aluminum hydroxide gel with the selected fatty acid, but the utilization of finished soaps specifically prepared for grease making by the double decomposition method has been the more general practice.

3—"Metallic Soaps," Mallinckrodt Chemical Works, St. Louis, Mo. (1946).

*Continued in June Issue*